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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in or relating to Methods and Apparatus for Drying Moist Sugar Cubes.

We, MASCHINENFABRIK BUCKAU R. WOLF AKTIENGESELLSCHAFT, of Lindenstrasse, Grevenbroich, a German Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to methods and apparatus for drying moist sugar cubes.

For manufacturing sugar cubes in moulds, the moist loose sugar introduced into the moulds is subjected to a pressure or vibration in order to condense it. The moist cubes of sugar which are expelled from these moulds pass to a conveyor where they are dried before they reach the packing machine. The moisture content of the sugar cubes, which fluctuates according to the manufacturing method between 1.5 and 3% by weight, is necessary to prevent the cubes of sugar from disintegrating during transport to the packing machine. The moisture must be removed from the cubes down to from 0.3 to 0.5% by weight so that the cubes acquire the necessary strength for packing.

Hitherto it has been considered that the processing medium or the processing temperature could not be allowed to exceed 80°C. because otherwise there was the danger of caramellisation and discoloration of the surface of the sugar cubes which assumed this temperature. The cubes were therefore dried in a hot air tunnel for prolonged periods of up to 8 hours at temperatures between 60 and 80°C. In order to dry large amounts of sugar cubes during this long period economically and without using excessive space, the hot air tunnels are arranged in several stages or tiers closely arranged one above the other, and are affected by laminar flows of hot air which flow at slow velocity over the sugar cubes arranged at small intervals. An increase in the air flow velocity is not possible, because the sugar cubes might be carried along by the moving air stream.

In hitherto known long-duration driers with laminar air flow, the cubes gradually assume the temperature of the air so that the temperature of the medium could not exceed 80°C. if the formation of caramel was to be avoided. In addition, these long-duration driers have the disadvantage of being very expensive to run because the movement of the cubes through several stages and the manufacture of the stages themselves requires complex equipment and drive equipment. In addition, intermediate stacking of sugar cubes is also necessary.

There are also known short-duration driers in which the sugar cubes are dried by means of high-frequency application, i.e., in an electric alternating field; however, these are also very expensive to run and require high installation and operating costs.

According to the present invention, there is provided a method of drying moist sugar cubes, wherein the sugar cubes encounter a plurality of gas jets having a temperature in the range of 110 to 220°C. and a velocity in the range of 15 to 50 metres per second for a period of time such that the moisture content of the sugar cubes is reduced to a value in the range of from 0.3 to 0.5% by weight.

The period of time for which the process must be operated to achieve the above desired moisture content may be easily determined empirically. Thus, for example, it is found that the optimum period of time

[P .]

for which the process is operated when the sugar cubes have been shaped by vibration, so that the cube structure is loose and the moist vapour is able to escape rapidly out of the sugar cubes is from 1 to 4 minutes.

Preferably air is used for the gas jets which impinge under moderate pressure to produce a forced distribution of the air and a uniform flow around all free surfaces of the cubes.

Owing to the high flow velocity, the temperature of the hot air may amount without risk to 110 to 220°C. so that the processing time may amount to only a few minutes. This is due to the fact that the moisture present in the sugar cubes is located in the coarse pores of the cubes in the form of free water. During the impact of the hot air jets on the cubes, first the free water in the surface pores is transformed into steam which is immediately removed so that there is no boundary layer on the outer surfaces of the cube which might delay the drying process. The free water inside the cube can continuously flow to the surface, keeping the same moist and cool, and is transformed into steam by the continuous application of hot air jets. In this way, there is a continuous moisture gradient towards the surface of the sugar cube. In spite of the high air temperature, the sugar cubes are not excessively heated.

According to a further embodiment of the invention, after the drying, the sugar cubes are treated in the same way with jets of cold air.

In order to utilize the drying air thermally and efficiently, the sugar cubes may be transported on a conveyor belt through a closed housing affected by hot drying air, the temperature of the drying air being above its dew point, wherein the drying air is recirculated, with the addition of fresh air, and reheated.

According to a preferred embodiment of the invention there is provided a plurality of drying zones, wherein the waste air is applied with or without reheating to the following drying zone with reference to the direction of travel of the sugar cubes and the waste air of the last drying zone is supplied at a temperature above its dew point with the addition of fresh air after reheating to the first drying zone.

The arrangement may also be such that the hot air is separately recirculated for every such zone.

Also according to the invention, there is provided apparatus for drying moist sugar cubes, the apparatus comprising a housing, means for conveying the sugar cubes to be treated through said housing, and a partition dividing the housing internally into a first chamber, which is arranged as a pressure chamber to which, in operation, a supply of gas under pressure is delivered, and a second chamber through which the sugar cubes are arranged to pass, the partition including means for allowing the gas to pass under pressure into the second chamber in the form of a plurality of gas jets which are so arranged that, in operation, the gas jets play upon the sugar cubes passing through said second chamber, there being further means for allowing the gas to escape from said second chamber. The sugar cubes may, if desired, be conveyed through the second chamber by means of an endless conveyer belt driven externally of said housing.

In order to ensure the uniform distribution of the air jets over the sugar cubes, a plurality of nozzles are provided which are arranged in rows in the bottom of the pressure chamber each row forming an acute angle with the longitudinal axis of the housing and the direction of travel of the sugar cubes.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:—

Fig. 1 is a diagrammatic longitudinal cross-section of one embodiment of the invention;

Fig. 2 is a cross-section taken along the line A—B of Fig. 1;

Fig. 3 is a view of a detail (indicated at *c*) of Fig. 1 drawn to a larger scale;

Fig. 4 is a plan view corresponding to Fig. 3;

Fig. 5 is a view similar to Fig. 1 of another embodiment; and

Fig. 6 is another view similar to Fig. 1 of a further embodiment.

As shown in Fig. 1, sugar cubes 1 are produced individually in a forming machine 2 (which is shown diagrammatically) and are deposited on an upper run 4 of a conveyor belt 3. The belt may be a closed steel plate belt, a screen plate belt or of some other suitable construction. However, a closed steel plate belt is preferred, due to better air guiding properties, because in a closed steel plate belt the air must be removed laterally. The belt 3 forms a lower run 5 and is guided over reversing rollers 6 and 7 located in supports 9 and 8 respectively. At the end of the run 4 remote from the forming machine 2 is a packing station 10, also shown diagrammatically. A processing housing 11, which encloses the major part of the runs 4 and 5, is divided by a jet or nozzle plate 12 and a base plate 13 into a pressure chamber 14 and a processing chamber 15. The upper run 4 of the belt 3 passes through the processing chamber 15 and forms thereby a return air conduit 16 under the upper run

4. For ventilating the sugar cubes 1, the cover of the housing 11 carries an air recirculator 17 and an air preheater 18. The air required for the sugar cubes is drawn in through fresh air ports 21 arranged in the side walls of the housing 11 and delivered to the fan 17 through a duct 20 connected to the base plate 13 of the housing 11. From here, the air flows through the preheater 18 and through a duct 19 into the pressure chamber 14 of the housing 1. The hot air is distributed uniformly into the processing chamber 15 through nozzles 23 formed in the nozzle plate 12, the hot air issuing from the plate 12 in the form of hot air jets 24 (Fig. 3) at high velocity and impinging on the surface of the sugar cubes 1, which are arranged to pass under the plate at a short distance therefrom. To prevent the hot air from being excessively saturated with moisture, there is provided, upstream of the air preheater 18, and on the delivery side of the fan 17, an outlet port 22, through which preferably approximately 10% of the recirculating air is exhausted. The same amount of 10% is inducted through the fresh air ports 21. In this manner, oversaturation of the air with moisture during its recirculation is avoided. The conduit 20 and the ports 21 and 22 contain control members for controlling the air supply.

The nozzles 23 are arranged in longitudinal rows 25 (Fig. 4) in the nozzle plate 12, the rows being offset at an acute angle relative to the direction of travel of the sugar cubes and to the longitudinal edge of the housing 11. This arrangement ensures uniform treatment of all the sugar cubes 1. The jets 24 issuing from the nozzles 23 expand in the direction of the cubes. When using round nozzles, such as are indicated at 23, the cone 24 of the air jet attains at the surface of the sugar cubes a diameter larger than that of the nozzle 23, as indicated at 26 in Fig. 3. The spacing of the nozzles 23 is such that these areas 26 overlap, as shown clearly in Fig. 4.

The forming machine 2 operates at a certain predetermined rhythm. The velocity of the belt must be accurately tuned to this rhythm. The length of the housing 11 depends on the moisture content of the sugar cubes to be treated, the temperature of the hot air and the velocity of the belt. The temperature of the hot air jets 24 is in the range of 110 to 220°C. and the air velocity is in the range of from 15 to 50 m/sec. However, preferably, the air velocity will be in the range of 25 to 30 m/sec. and the air temperature in the range of 150 to 160°C, because this combination results in the optimum treatment of the sugar cubes.

In order to improve the thermal efficiency of the installation, it is also possible to use so-called sectionalized air recirculation. To this end, the housing 11 is divided by partitions 30 and 31 (Fig. 5) into three zones 27, 28 and 29. Each zone has its own fan 32, 33 and 34 and its own air preheater 35, 36 and 37, respectively. The required fresh air is supplied through an inlet port 38 and a duct 39 to the first fan 32. Waste air escapes through an outlet port 40 at the other end of the housing.

In the embodiment illustrated in Fig. 5, the fresh air drawn in by the fan 32 is heated in the air preheater 35 and supplied through a conduit 41 to the pressure chamber 14 of the zone 27. The used hot air is drawn off through the return air conduit 16 by means of the duct 42 and is supplied through the fan 33 and air preheater 36 through a conduit 43 to the zone 28. From here, the air flows via the conduit 44, fan 34, air preheater 37 and duct 45 to the third zone 29, and after being used in this zone 29, back through a conduit 46 to the fan 32. During this recirculation of the air, a small proportion is continuously exhausted through the outlet port 40, and the same amount is replaced through the fresh air inlet port 38. Preferably this renewal of air amounts to approximately 10% of the total air circulating in the housing.

The apparatus illustrated in Fig. 5 may also be used to provide stepped heating of the sugar cubes. To this end, the air preheaters 36 and 37 are switched off wholly or partly. This results in the following air flow:—

The air drawn in through the conduit 39 is heated in the air preheater to, say, 180°C. After use, the air has only a temperature of 150°C and is inducted at this temperature through the conduit 42 and applied at this temperature of 150°C to the second zone 28, since the air preheater 36 is switched off. From the air return channel 16 of zone 28, the waste air leaves this zone at a temperature of only 120°C and is supplied at this temperature to the zone 29. After use in this zone, the air temperature has dropped to 110°C and flows at this temperature back through the conduit 46 to the fan 32. It is also possible to effect the air preheating in steps in such a manner that the sugar cubes are heated in the zone 27 at a lower temperature than in the zone 28 and that the zone 29 has then again the same temperature as the first zone 27. This procedure ensures that the sugar cubes introduced with a high moisture content into the zone 27, cannot become superficially encrusted.

Fig. 6 shows also a subdivision of the housing 11 into three zones 27, 28 and 29, but in this embodiment each zone has its own separate air recirculation system. Each zone has a separate suction conduit 50, 51

and 52 and separate fresh air conduits 47, 48 and 49, respectively. In addition, each zone has its own waste air outlet ports 53, 54 and 55 respectively, arranged, as in Fig. 1, upstream of the air preheaters 35, 36 and 37. Also in this arrangement, the amount of air expelled from the outlet ports 53, 54 and 55 is balanced by the amount of air drawn in through the conduits 47, 48 and 49, respectively. In the embodiment illustrated in Fig. 6, the last zone 29 may also be used as cooling zone. To this end, the air preheater 37 is switched off and air is drawn in through the fresh air socket 49 in amounts required for the treatment, i.e., cooling of the sugar cubes 1. This requires a separate waste air outlet port (not shown), which is arranged in a manner similar to that of the outlet port 40 in Fig. 5. The amount of fresh air drawn in for cooling corresponds to the amount of used air expelled. The heated used air may then be used for the further stages of the operation, for example, by supplying it again to the preheater.

It is to be understood that the invention is not limited to the embodiments hereinbefore described, and any other air circulating circuit may be employed which is suitable for treating the sugar cubes in a thermally efficient manner. Although the above embodiments have been described in relation to the use of air as the treating gas, it will be appreciated that, with suitable modifications, any other appropriate gas may be employed.

Thus, there is produced a method of drying moist sugar cubes in a considerably reduced period of time.

WHAT WE CLAIM IS:—

1. A method of drying moist sugar cubes, wherein the sugar cubes encounter a plurality of gas jets having a temperature in the range of 110 to 220°C and a velocity in the range of 15 to 50 metres per second for a period of time such that the moisture content of the sugar cubes is reduced to from 0.3 to 0.5% by weight.

2. A method as claimed in claim 1, wherein the cubes are simultaneously moved relative to said gas jets.

3. A method as claimed in claim 1 or 2, wherein the gas jets are arranged in a closely packed manner.

4. A method as claimed in any one of the preceding claims, wherein the gas jets are arranged to play upon the sugar cubes from above.

5. A method as claimed in any one of the preceding claims, wherein the gas jets have a temperature in the range of 150 to 160°C, and a velocity in the range of 25 to 30 metres per second.

6. A method as claimed in any one of the preceding claims, wherein the gas from the gas jets is maintained at a temperature above its dew point, mixed with a fresh supply of gas, recirculated and reheated to a temperature in the range of from 110 to 220°C.

7. A method as claimed in any one of the preceding claims, wherein the sugar cubes are subsequently treated with jets of cooler gas in a manner similar to their treatment by the first mentioned jets.

8. A method as claimed in claim 6 or 7, wherein there is provided a plurality of drying zones, the gas for the gas jets passing from one zone to the next and the waste gas from the last drying zone being delivered with the addition of fresh gas and after reheating, to the first drying zone.

9. A method as claimed in claim 6 or 7, wherein there is provided a plurality of drying zones the gas for the gas jets in each drying zone being separately recirculated.

10. A method as claimed in claim 7 or in claim 8 or 9 when dependent upon claim 7, wherein the cooler gas is air.

11. A method as claimed in any one of the preceding claims, wherein the gas for the gas jets is air.

12. A method of drying moist sugar cubes substantially as hereinbefore described with reference to Figs. 1 to 4 of the accompanying drawings.

13. A method of drying moist sugar cubes substantially as hereinbefore described with reference to Fig. 5 of the accompanying drawings.

14. A method of drying moist sugar cubes substantially as hereinbefore described with reference to Fig. 6 of the accompanying drawings.

15. Apparatus for drying moist sugar cubes, the apparatus comprising a housing, means for conveying the sugar cubes to be treated through said housing, and a partition dividing the housing internally into a first chamber, which is arranged as a pressure chamber to which, in operation, a supply of gas under pressure is delivered, and a second chamber through which the sugar cubes are arranged to pass, the partition including means for allowing the gas to pass under pressure into the second chamber in the form of a plurality of gas jets which are so arranged that, in operation, the gas jets play upon the sugar cubes passing through said second chamber, there being further means for allowing the gas to escape from said second chamber.

16. Apparatus as claimed in claim 15, wherein the first chamber is arranged above said second chamber.

17. Apparatus as claimed in claim 15 or 16, wherein the conveying means is in the form of an endless conveyor belt, driven externally of said housing.

18. Apparatus as claimed in any one of claims 15 to 17, wherein the gas jet means included in said partition is in the form of a plurality of nozzles which are arranged in a closely packed manner.

19. Apparatus as claimed in claim 18, wherein the nozzles are arranged in rows which form an acute angle to the direction of travel of the sugar cubes.

20. Apparatus as claimed in any one of claims 15 to 19, wherein there is provided means for recirculating the gas from said second chamber for reintroduction into said first chamber, said recirculating means including means for introducing a supply of fresh gas into the circuit, and means for exhausting a proportion of the recirculated gas mixed with the fresh gas.

21. Apparatus for drying moist sugar cubes substantially as hereinbefore described with reference to and as illustrated in Figs. 1 to 4 of the accompanying drawings.

22. Apparatus for drying moist sugar cubes substantially as hereinbefore described with reference to and as illustrated in Fig. 5 of the accompanying drawings.

23. Apparatus for drying moist sugar cubes substantially as hereinbefore described with reference to and as illustrated in Fig. 6 of the accompanying drawings.

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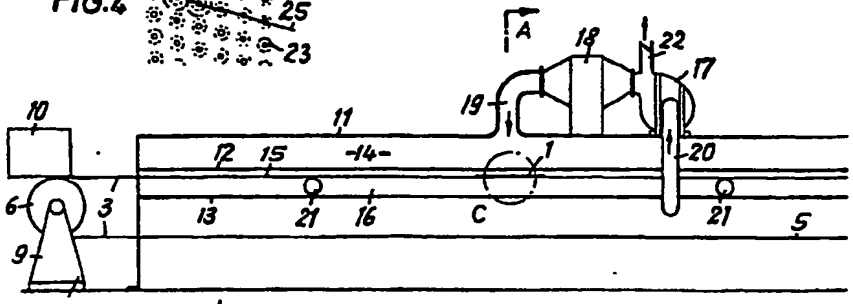
FIG.4

FIG.1



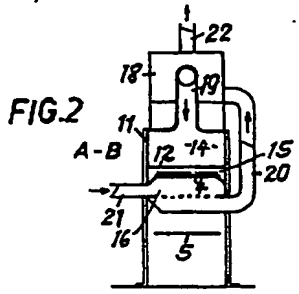
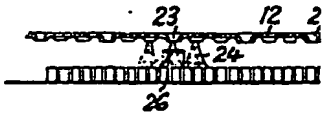
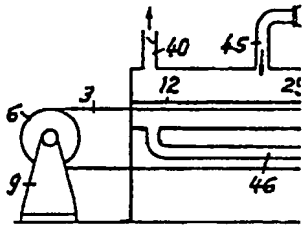


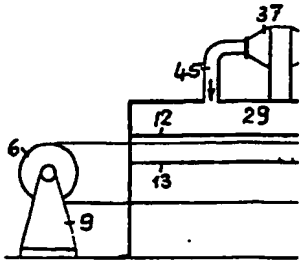
FIG.2

B

FIG.3







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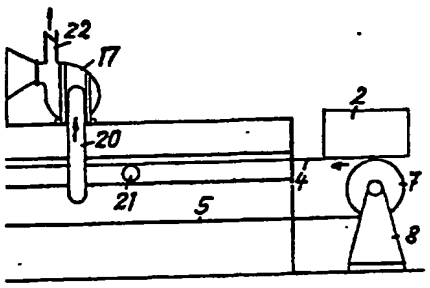

FIG. 3

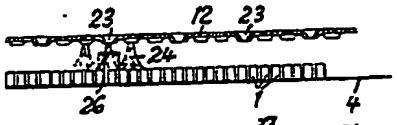

FIG. 5

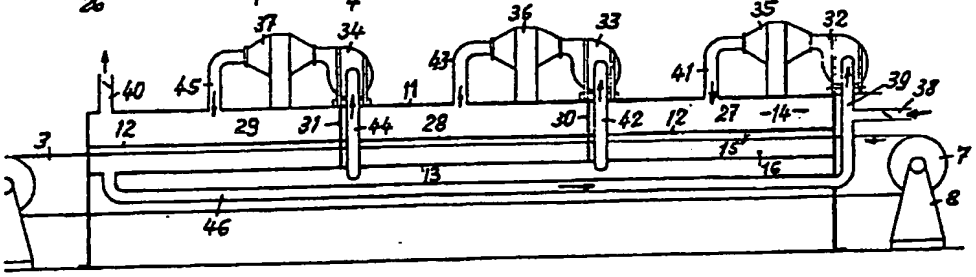

FIG. 6

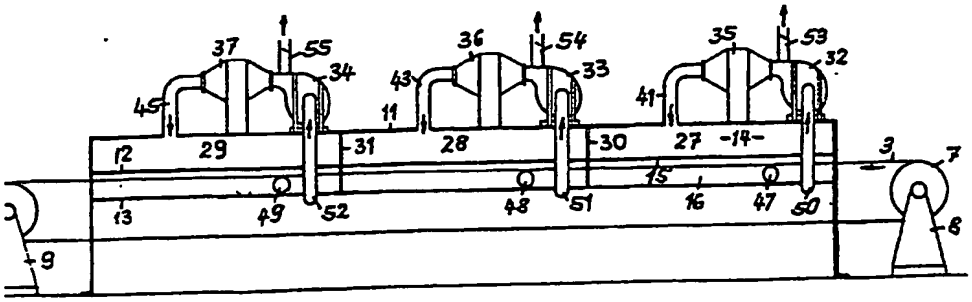

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FIG.4

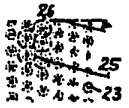

FIG.1

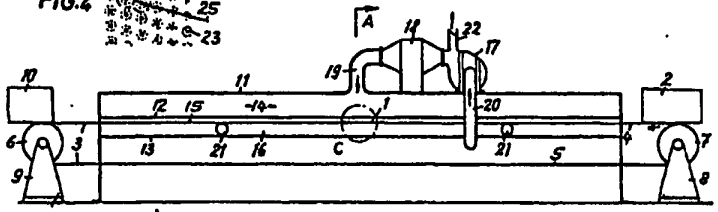

FIG.2

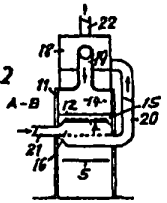

FIG.3

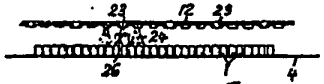

FIG.5

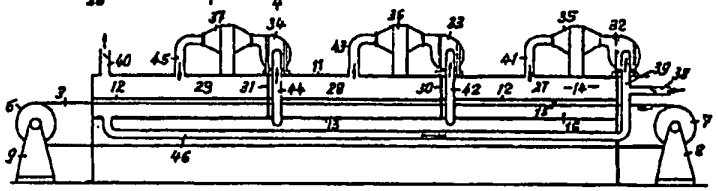

FIG.6